Application of IRTAM to Support ISS Program Safety

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Extended Abstract

The International Space Station (ISS) orbits near the F-peak of the ionosphere (~400 km altitude). Generally, satellites orbiting at this altitude would have a floating potential (FP) of ~-1 V due to the electron temperature (Te). However, the ISS has 8 large negatively grounded 160 V solar array wings (SAW) that collect a significant electron current from the ionosphere. This current drives the ISS FP much more negative during insolation and is highly dependent on the electron density (Ne). Also, due to the size of the ISS, magnetic inductance caused by the geomagnetic field produces a delta potential up to 40 V across the truss, possibly producing positive potentials. During Extravehicular Activity (EVA) the negative FP can lead to an arcing hazard when it exceeds -45.5 V, and the positive FP can produce a DC current high enough to stimulate the astronaut's muscles and also cause a hazard. Data collected from the Floating Potential Monitoring Unit (FPMU) have shown that the probability of either of these hazards occurring during times with quiet to moderately disturbed geomagnetic activity is low enough to no longer be considered a risk. However, a study of the ionosphere Ne during severe geomagnetic storm activity has shown that the Ne can be enhanced by a factor of 6 in the ISS orbit. As a result, the ISS Safety Review Panel (SRP) requires that ionospheric conditions be monitored using the FPMU in conjunction with the ISS Plasma Interaction Model (PIM) to determine if a severe geomagnetic storm could result in a plasma environment that could produce a hazard.

A "Real-Time" plasma hazard assessment process was developed to support ISS Program real-time decision making providing constraint relief information for EVAs planning and operations. This process incorporates "real time" ionospheric conditions, ISS solar arrays' orientation, ISS flight attitude, and where the EVA will be performed on the ISS. This assessment requires real time data that is presently provided by the FPMU including ISS floating potential, along with ionospheric Ne and Te, in order to determine the present environment. Once the present environment conditions are known to be either above, below, or near the current IRI values, the IRI is used to forecast what the environment could become in the event of a severe geomagnetic storm.

If the FPMU should fail, the Space Environments team needs another source of data which is utilized to support a short-term forecast for EVAs. The IRI Real-Time Assimilative Mapping (IRTAM) model is an ionospheric model that uses real time measurements from ~70 digisondes to produce foF2 and hmF2 global maps in 15 minute cadence. The Boeing Space Environments team has used the IRI coefficients produced in IRTAM to calculate the Ne along the ISS orbital track. The results of the IRTAM model have been compared to FPMU measurements and show excellent agreement (figure 1). IRTAM has been identified as a potential FPMU back-up system will be used as a backup for the FPMU to support the ISS Program following completion of an FPMU/IRTAM validation campaign.

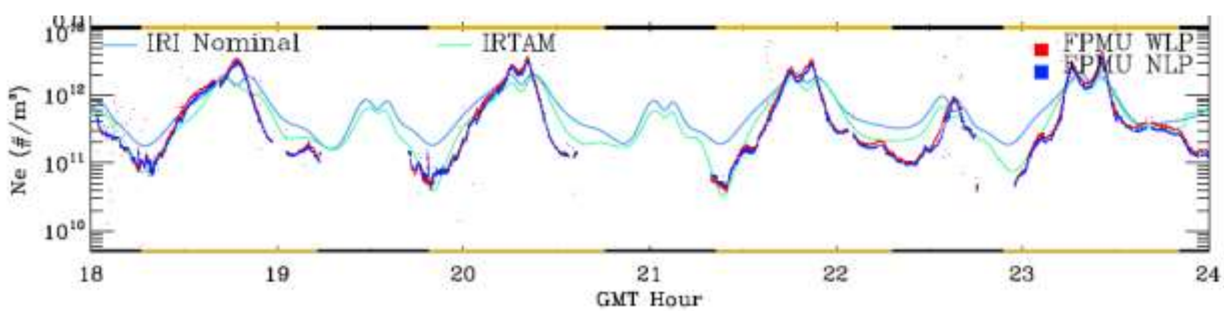

Figure 1. Plot of FPMU Ne from the Wide-sweep Langmuir probe (red), Narrow-sweep Langmuir Probe (dark blue), IRI model (light blue) and IRTAM (green).